The Predicted Impact of Ocean Acidification on Antarctic Bivalves

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Abstract #0855

Recent studies suggest that the Southern Ocean could become entirely undersaturated with respect to aragonite between 2030 and 2050 (Orr et al., 2005; McNeil & Matear, 2008).

These predictions have major ecological implications for calcifying organisms. Current work has focused upon shelled pteropods, while little is known about benthic communities.

By examining the mineralogy, microstructure and bathymetry data for 30 bivalve families located within the Antarctic Convergence Zone, we found two major patterns that have implications for bivalve survival in light of the 2050/2030 predictions:

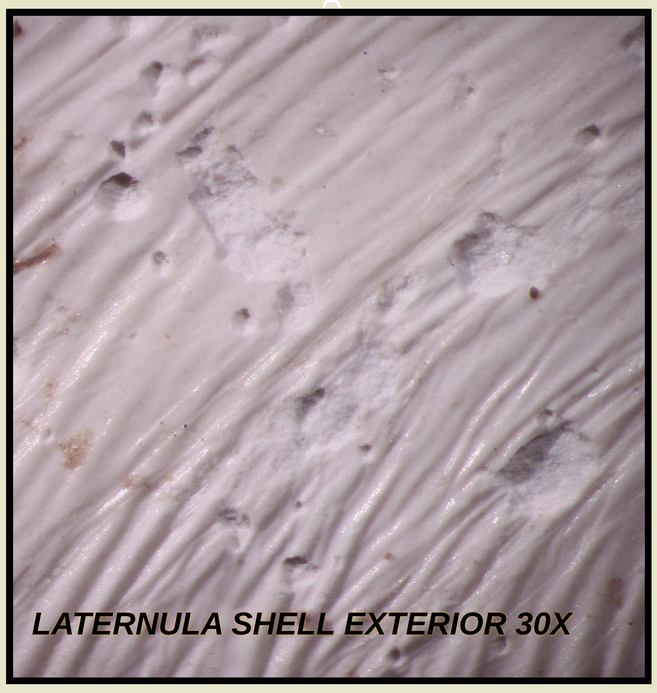
1) Fourteen bivalve families have weaker aragonite microstructures but nine families have dissolution-resistant microstructure; five families may persist that have calcite layers, but more work is needed to be certain.

2) Under present conditions 58% of the families contain genera living in aragonitic undersaturated (cold-water) conditions.

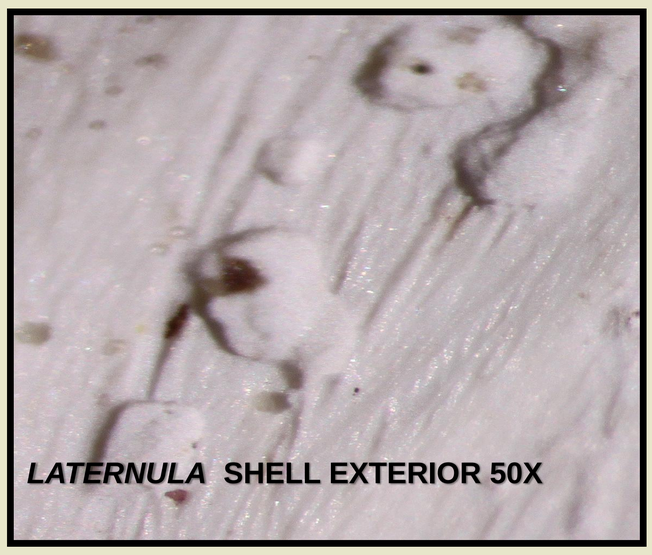
Case Study

A case study conducted in Explorers Cove, Antarctica, in 2008 revealed pitting and dissolution in living specimens of *Laternula elliptica* (Family: Laternulidae; aragonitic composite prismatic inner and outer shell layers) in shallow waters, while living *Adamussium colbecki* (Family: Propeamussidae; composite calcite/aragonite shell layers) do not show chemical dissolution. *Laternula* is restricted to shallow water, and *A. colbecki* has a much wider bathymetric distribution.

A



***LATERNULA* SHELL EXTERIOR 30X**



***LATERNULA* SHELL EXTERIOR 50X**

***ADAMUSSIUM* SHELL EXTERIOR 30X**
(LIGHT AREAS ARE DIATOMS & FORAMS)

Introduction

While the effects of ocean acidification on high-latitude calcareous plankton are just starting to be studied, much less is known about the immediate impact of ocean acidification on high-latitude benthic communities. The first effects of aragonite undersaturation is predicted to be between 2030 (McNeil & Matear, 2008) and 2050 (Orr et al., 2005) in waters surrounding Antarctica.

We focused our study within the Antarctic Convergence Zone to determine how Antarctica's bivalve mollusks will be affected based upon their mineralogy, microstructure, and depth distributions. Currently up to 58% of the 31 families living in these waters may already be living in undersaturated aragonitic conditions because of deep-sea conditions (aragonite goes into solution in cold, high-pressure regions of the deep sea). Many mollusks in deep sea and shallower regions may not possess the needed microstructures to survive projected acidified conditions.

Methods

Data Collection

Data were collected using the Smithsonian Institution's online database of Antarctic Invertebrates[1]. We focused our selection only on those families found south of the circumpolar Antarctic Convergence Zone.

Microstructure & Dissolution

Mineralogies and microstructures of each family where collected where data were available (Taylor & Layman, 1972). Using Harper (2000), we devised a table showing each microstructure's resistance to dissolution (Fig. 1). Using this table we were able to estimate which families are most likely to be vulnerable to the predicted undersaturated aragonitic conditions. Also, images depicting differing microstructures as well as varying stages of dissolution were selected for display from the Smithsonian website (Fig. 2).

Bathymetry

We created a bathymetric index consisting of four zones to show depth relations among families and their respective shell compositions. These were generalized based upon Aldea (2007). Depending on the depths at which specimens were collected, each family was placed within one or more of these zones. Represented are the Continental Shelf, Inner and Outer Slopes and Abyssal Plain (Fig. 3).

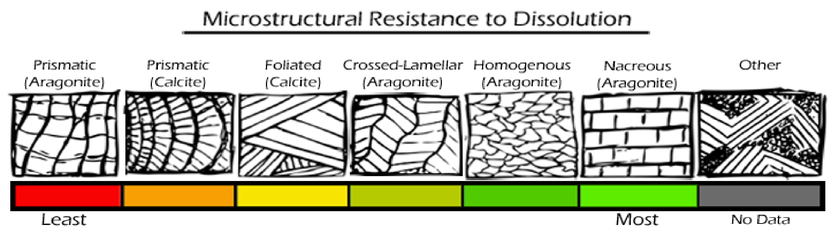


Figure 1. Chart depicting each of the studied microstructure resistance to dissolution in acidified conditions (Red indicates those most vulnerable to dissolution; Green indicates those most resistant; Gray represents those microstructures where no dissolution data were available. Sketches after Taylor & Layman (1972).

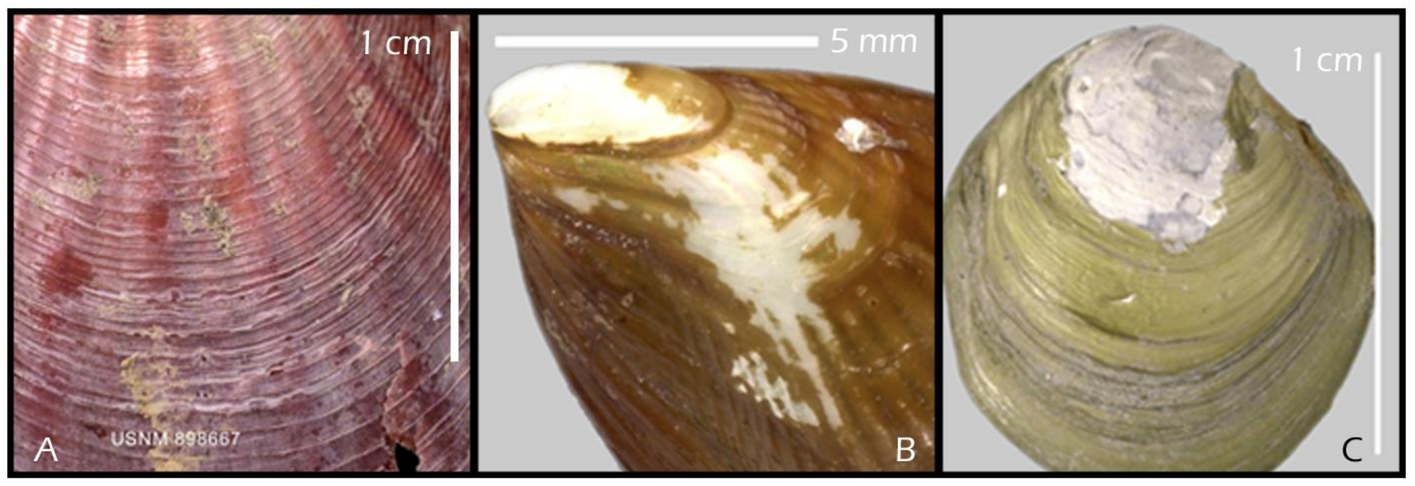


Figure 2. Shells of varying mineralogy and microstructure showing various stages of dissolution. A) A. colbecki (Family Propeamussidae) showing little to no signs of dissolution. Shell is composite calcite/aragonite with foliated microstructure. B) A. Ater (Family Mytilidae). Composite calcite/aragonite shell with prismatic microstructure showing signs of dissolution on and around the umbones. C) T. falklandica (Family Thyasiridae). Fully aragonite shell with prismatic microstructure (least resistant microstructure) displaying extensive dissolution of the umbones. Photos from the Smithsonian Institution website.

Data and Discussion

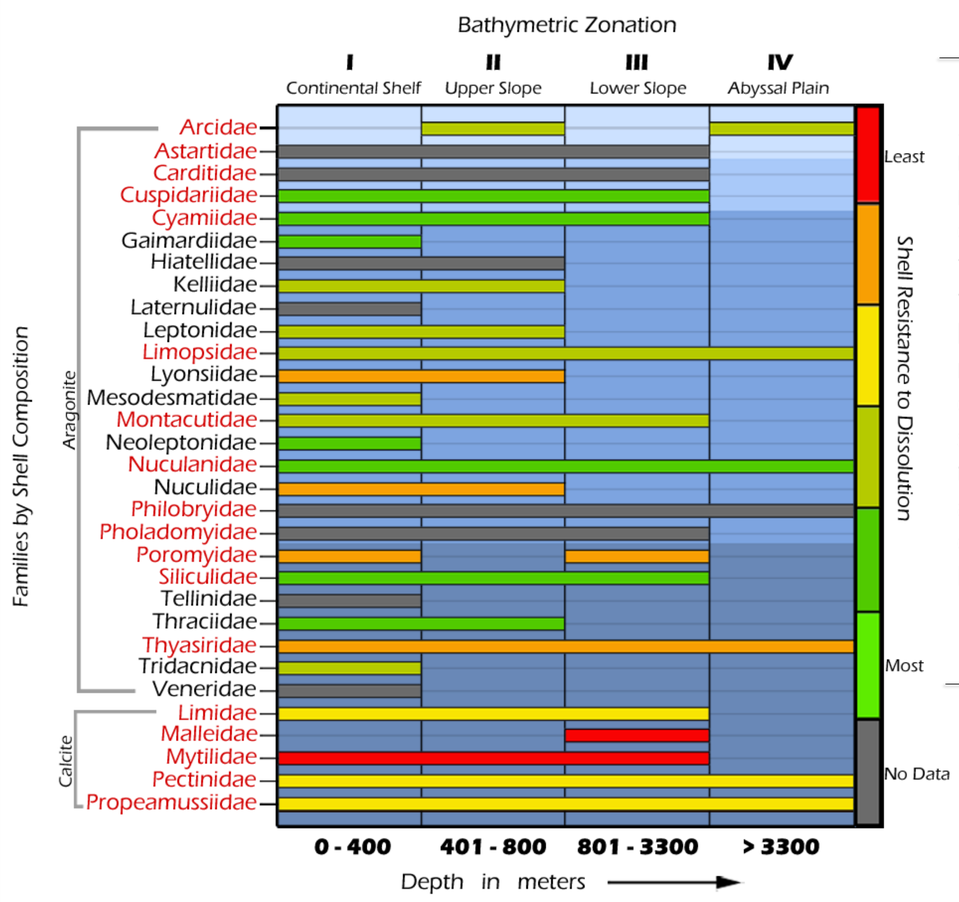


Figure 3. Bathymetric ranking of families by mineralogy and microstructure. Families in red are those containing genera which may be presently living in undersaturated conditions with respect to aragonite. Graph bar colors represent shell resistance to dissolution based upon their typified microstructure.

Results

Of the 25 aragonitic families within Antarctic waters, 14 possess experimentally-demonstrated weaker shell microstructures (i.e., prismatic and crossed-lamellar) and may be immediately affected by the undersaturated conditions predicted for 2050/2030. The remaining nine families have more resistant aragonitic microstructures (i.e., fine-grained homogenous and nacreous) and may persist longer. The five bivalve families that have composite microstructures, i.e., those with inner or outer shell layers of calcite in association with aragonite, are characteristic of shallow shelf to abyssal zones; we had originally predicted that these families will persist in relation to the modeled acidification events. However, the data appears to show otherwise as is shown in Figure 3.

Conclusions

The aim of this study was to investigate the impact of predicted ocean acidification on benthic bivalves in waters surrounding Antarctica. There are 25 families whose shells are composed of only aragonite. Conventional wisdom implies that those organisms should be the most vulnerable to dissolution in acidified conditions; however, as we compiled our data it became apparent that many of the strongest microstructural types did not contain calcite (i.e., Harper 2000). Furthermore, there were only dissolution data available for six microstructural types. More research is needed on how the various microstructural types resist dissolution to gain better insight on how these organisms will be affected by ocean acidification.

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